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[54] **METHODS AND APPARATUS FOR REGISTERING CT-SCAN DATA TO MULTIPLE FLUOROSCOPIC IMAGES**

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[58] **Field of Search** 600/425, 407, 600/473, 414, 417; 378/205, 206, 207, 42, 190; 606/130; 382/128, 132, 285, 294; 901/14; 356/395–397, 375

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[57] **ABSTRACT**

A method and system is disclosed for registering two dimensional fluoroscopic images with a three dimensional model of a surgical tissue of interest. The method includes steps of: (a) generating, from CT or MRI data, a three dimensional model of a surgical tissue of interest; (b) obtaining at least two, two dimensional, preferably fluoroscopic, x-ray images representing at least two views of the surgical tissue of interest, the images containing radio-opaque markers for associating an image coordinate system with a surgical (robot) coordinate system; (c) detecting the presence of contours of the surgical tissue of interest in each of the at least two views; (d) deriving bundles of three dimensional lines that pass through the detected contours; and (e) interactively matching three dimensional points on three dimensional silhouette curves obtained from the three dimensional model with the bundles of three dimensional lines until the three dimensional model is registered within the surgical coordinate system to a predetermined level of accuracy. The step of iteratively matching includes steps of: defining a distance between surfaces of the model and a beam of three dimensional lines that approach the surfaces; and finding a pose of the surfaces that minimizes a distance to the lines using, preferably, a statistically robust method, thereby providing a desired registration between a surgical robot and a preoperative treatment plan.

35 Claims, 17 Drawing Sheets